What is claimed is:

1. A system for redirecting optical signals, said system comprising:

at least one substrate having a first surface;

at least one reflective microstructure array formed on said substrate, said reflective microstructure array including at least one reflective microstructure, each said reflective microstructure of said reflective microstructure array including an optically reflective surface and being positionable with respect to the first surface of said substrate in at least one orientation wherein the reflective surface thereof is positioned to redirect an optical signal from at least one originating location to at least one target location, each said orientation of each said reflective microstructure being defined by an associated unit normal vector orthogonal to the reflective surface thereof;

a set of unit normal vectors comprising substantially all of the unit normal vectors associated with each said orientation of each said reflective microstructure; and

an average normal vector associated with said reflective microstructure array, said average normal vector comprising the average of the unit normal vectors in said set of unit normal vectors;

wherein an average normal vector associated with said reflective microstructure array forms an acute angle with a vector normal to the first surface of said substrate, said angle being greater than five degrees.

2. The system of claim 1 wherein said angle is greater than ten degrees and less than eighty degrees.

3. The system of claim 1 wherein each said reflective microstructure of said reflective microstructure array is positionable to selectively switch an optical signal on and off at a target location.

4. The system of claim 1 wherein each said originating location and each said target location comprise an optical port, said reflective microstructures of said reflective microstructure array being positionable in orientations required to redirect optical signals between selected optical ports.

5. The system of claim 4 wherein at least a portion of said optical ports are arranged in at least one array of optical ports, said optical ports within said array of optical ports being arranged in a first plane.

6. The system of claim 5 wherein at least one of said plurality of optical ports is positioned outside of said first plane.

7. The system of claim 4 wherein said system includes at least two reflective microstructure arrays, and wherein said reflective microstructures of said reflective microstructure arrays are positionable to redirect optical signals between selected groups of optical ports associated with respective reflective microstructure arrays.

8. The system of claim 1 wherein said system comprises an optical protection switch.

9. The system of claim 1 wherein said system comprises an optical signal multiplexer.

10. The system of claim 1 wherein said system comprises an optical signal demultiplexer.

11. The system of claim 1 wherein said target location comprises at least one of an optical port, a positionable reflective microstructure, an optical sensor, a fluorescent screen, a polarizer, a diffraction grating, a portion of a person's anatomy, a target cell in an aqueous solution, a prism, and an optical signal attenuator.

12. The system of claim 1 further comprising:

a fixed reflective surface that is fixed in a position relative to the reflective microstructure array to provide an optical pathway between the target location and the reflective microstructure array.

13. The system of claim 1 wherein said system includes at least two reflective microstructure arrays and said system further comprises:

a fixed reflective surface fixed relative to said reflective microstructure arrays, said fixed reflective surface being positioned to provide an optical pathway between said reflective microstructure arrays.

14. The system of claim 1 wherein said system includes at least two substrates and at least two reflective microstructure arrays, each reflective microstructure array being formed on a separate one of said substrates, at least two of said substrates being positioned such that vectors normal to the first surfaces thereof are parallel.

15. The system of claim 1 wherein said system includes at least two substrates and at least two reflective microstructure arrays, each said reflective microstructure array being formed on a separate one of said substrates, at least two of said substrates being positioned such that vectors normal to the first surfaces thereof are oriented at a non-zero angle with respect to each other.

16. The system of claim 1 wherein said reflective microstructures of said at least one reflective microstructure array are arranged in a rectangular pattern of rows and columns.

17. The system of claim 1 wherein the vector normal to the first surface of said substrate is parallel with at least one of an optical signal beam incident on said reflective microstructure and the optical signal beam reflected from said reflective microstructure.

18. The system of claim 1 wherein the vector normal to the first surface of said substrate forms a non-zero angle with both an optical signal beam incident on said reflective microstructure and the optical signal beam reflected from said reflective microstructure.

19. The system of claim 1 wherein an effective packing density of said reflective microstructure array exceeds a real packing density of said reflective microstructure array.

20. The system of claim 1 wherein each said reflective microstructure of said reflective microstructure array is positionable with at least one degree of freedom.

21. The system of claim 1 wherein each said reflective microstructure of said reflective microstructure array is positionable with two degrees of freedom.

22. The system of claim 1 wherein each said reflective microstructure of said reflective microstructure array is positionable with open loop control.

23. The system of claim 1 wherein said optically reflective surface of each said reflective microstructure of said reflective microstructure array comprises an optically reflective coating.

24. The system of claim 1 wherein said reflective microstructure array includes at least one microactuator formed on said substrate for each said reflective microstructure of said array, each said reflective microstructure being operatively coupled with at least one of said microactuators.

25. The system of claim 24 wherein said at least one microactuator comprises at least one of an electrostatic actuator, an electromagnetic actuator, a thermal actuator, and a magnetic actuator.

26. The system of claim 1 wherein at least a portion of said reflective microstructure array is formed on said using at least one of sacrificial surface micromachining, bulk micromachining, and LIGA.

27. A system for redirecting optical signals, said system comprising:

at least one substrate having a first surface;

at least one reflective microstructure array formed on said substrate, said reflective microstructure array including at least one reflective microstructure, each said reflective microstructure of said reflective microstructure array including an optically reflective surface and being positionable with respect to the first surface of said substrate in at least one orientation wherein the reflective surface thereof is positioned to redirect an optical signal from at least one originating location to at least one target location, each said orientation of each said reflective microstructure being defined by an associated unit normal vector orthogonal to the reflective surface thereof;

a set of unit normal vectors comprising substantially all of the unit normal vectors associated with each said orientation of each said reflective microstructure; and

an average normal vector associated with said reflective microstructure array, said average normal vector comprising the average of the unit normal vectors in said set of unit normal vectors;

wherein said average normal vector associated with said reflective microstructure array forms a first angle with a vector normal to the first surface of said substrate, said first angle being greater than five degrees; and

wherein, a set of second angles measured between projections of each unit normal vector in said set of unit normal vectors onto the first surface of said substrate and a reference axis defined on the first surface of said substrate span a range that is greater than two degrees.

28. The system of claim 27 wherein said first angle is greater than ten degrees.

29. The system of claim 27 wherein said range that is greater than ten degrees.

30. A system for redirecting optical signals, said system comprising:

at least one substrate having a first surface; and

at least one reflective microstructure array formed on said substrate, said reflective microstructure array including at least one reflective microstructure, each said reflective microstructure of said reflective microstructure array including an optically reflective surface and being positionable with respect to the first surface of said substrate in at least one orientation wherein the reflective surface thereof is positioned to redirect an optical signal from at least one originating location to at least one target location, each said orientation of each said reflective microstructure being defined by an associated unit normal vector orthogonal to the reflective surface thereof; and

a set of unit normal vectors comprising substantially all of the unit normal vectors associated with each said orientation of each said reflective microstructure;

wherein, a set of angles measured between projections of each unit normal vector in said set of unit normal vectors onto the first surface of said substrate and a reference axis defined on the first surface of said substrate span a range that is greater than two degrees and less than one-hundred eighty degrees.

31. The system of claim 30 wherein said range is greater than ten degrees and less than one-hundred twenty degrees.

32. An optical cross connect for switching optical signals between a first plurality of optical ports and a second plurality of optical ports, said optical cross connect comprising:

a first substrate having a surface facing the first plurality of optical ports;

a second substrate having a surface facing the second plurality of optical ports;

a first off axis reflective microstructure array formed on the surface of said first substrate, wherein said first off axis reflective microstructure array includes a plurality of reflective microstructures, each said reflective microstructure of said first off axis reflective microstructure array being associated with one of said first plurality of optical ports and including an optically reflective surface; and

a second off axis reflective microstructure array formed on the surface of said second substrate, wherein said second off axis reflective microstructure array includes a plurality of reflective microstructures, each said reflective microstructure of said second off axis reflective microstructure array being associated with one of said second plurality of optical ports and including an optically reflective surface;

each said reflective microstructure of said first off axis reflective microstructure array being positionable to orient its reflective surface to reflect an optical signal receivable from its associated optical port to the reflective surface of at least one reflective microstructure of said second off axis reflective microstructure array and positionable to orient its reflective surface to reflect an optical signal receivable from at least one reflective microstructure of said second off axis reflective microstructure array to its associated optical port;

each said reflective microstructure of said second off axis reflective microstructure array being positionable to orient its reflective surface to reflect an optical signal receivable from its associated optical port to the reflective surface of at least one reflective microstructure of said first off axis reflective microstructure array and positionable to orient its reflective surface to reflect an optical signal receivable from at least one reflective microstructure of said first off axis reflective microstructure array to its associated optical port.

33. The optical cross connect of Claim 32 wherein said first and second pluralities of optical ports are positioned on a first side of a free space switch interface and said first and second substrates are positioned on a second side of the free space switch interface opposite the first side of the free space switch interface.

34. The optical cross connect of Claim 33 wherein said first and second pluralities of optical ports are laterally spaced apart from one another on the first side of the free space switch interface and wherein said first and second substrates are laterally spaced apart from one another on the second side of the free space switch interface.

35. The optical cross connect of Claim 34 further comprising:

a reflective surface positioned on the first side of the free space switch interface between said first and second pluralities of optical ports.

36. The optical cross connect of Claim 35 wherein said first and second pluralities of optical ports are arranged in rows and columns and said reflective microstructures of said first and second off axis reflective microstructure arrays are arranged in corresponding rows and columns on said first and second substrates.

37. The optical cross connect of Claim 36 wherein a minimum pitch S of said reflective microstructures along said rows is specified by the following equation:

$$S \geq D\frac{\cos\theta}{\cos 2\theta}$$

wherein D is the dimension of said reflective microstructures measured in the direction of said rows and θ is the tilt angle of each said off axis reflective microstructure with respect to said first and second substrates, respectively, about an axis orthogonal to the direction of said rows.

38. The optical cross connect of Claim 37 wherein a minimum distance H measured from the first side to the second side of the free space switch interface is specified by the following equation:

$$H \geq 0.75 \frac{mD}{\sin\theta}$$

wherein m is the number of said reflective microstructures in said rows.

39. The optical cross connect of Claim 38 wherein a maximum pitch S' of said reflective microstructures along said columns is specified by the following equation:

$$S' \leq \frac{m}{n} S \tan(\alpha)$$

wherein n is the number of said reflective microstructures in said columns and α is the tilt angle of each said reflective microstructure with respect to said first and second substrates, respectively, about an axis orthogonal to the direction of said columns.

40. The optical cross connect of Claim 32 wherein said first plurality of optical ports and said second substrate are positioned on a first side of a free space switch interface and said second plurality of optical ports and said first substrate are positioned on a second side of the free space switch interface opposite the first side of the free space switch interface.

41. The optical cross connect of Claim 40 wherein said first and second pluralities of optical ports are arranged in rows and columns and said reflective microstructures of said first and second off axis reflective microstructure arrays are arranged in corresponding rows and columns on said first and second substrates.

42. The optical cross connect of Claim 41 wherein a minimum distance H measured from the first side to the second side of the free space switch interface is specified by the following equation:

$$H \geq \frac{mD}{\sin\theta}$$

wherein m is the number of reflective microstructures in said rows, D is the dimension of said reflective microstructures measured in the direction of said rows, and θ is the tilt angle of each said reflective microstructure with respect to said first and second substrates, respectively, about an axis orthogonal to the direction of said rows.

43. The optical cross connect of Claim 42 wherein a required tilt angle α of each said reflective microstructure with respect to said first and second substrates, respectively, about an axis orthogonal to the direction of said columns is approximately ninety degrees.

44. The optical cross connect of Claim 32 wherein said first and second pluralities of optical ports and said first and second substrates are positioned on respective sides of a polyhedral free space switch interface.

45. The optical cross connect of Claim 44 wherein said first and second pluralities of optical ports are arranged in rows and columns and said reflective microstructures of said first and second off axis reflective microstructure arrays are arranged in corresponding rows and columns on said first and second substrates.

46. A method of redirecting optical signals from originating locations to target locations, said method comprising the steps of:

positioning each reflective microstructure of a reflective microstructure array fabricated on a first surface of a substrate in an appropriate orientation with respect to the first surface of the substrate for receiving an optical signal from a specified originating location and reflecting the optical signal to a specified target location, the orientation of each reflective microstructure being defined by an associated unit normal vector that is oriented orthogonal to a reflective surface of each reflective microstructure;

receiving optical signals on the reflective surfaces of the reflective microstructures from the specified originating locations for which the reflective microstructures are appropriately oriented; and

reflecting the optical signals received on the reflective surfaces of the reflective microstructures to the specified target locations for which the reflective microstructures appropriately oriented;

wherein, in said positioning step, an average normal vector comprising substantially all of the unit normal vectors associated with the orientations of the reflective microstructures forms an acute angle with a vector normal to the first surface of the substrate, said angle being greater than five degrees.

47. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified target locations comprises a reflective microstructure of the reflective microstructure array.

48. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified originating locations comprises a reflective microstructure of the reflective microstructure array.

49. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified originating locations comprises a reflective microstructure of another reflective microstructure array.

50. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified target locations comprises a reflective microstructure of another reflective microstructure array.

51. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified target locations comprises a fixed reflective surface fixed relative to the reflective microstructure array.

52. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified originating locations comprises a fixed reflective surface fixed relative to the reflective microstructure array.

53. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified originating locations comprises an optical port.

54. The method of claim 46 wherein in said step of positioning each reflective microstructure, at least one of the specified target locations comprises an optical port.

55. The method of claim 46 wherein said angle is greater than ten degrees and less than eighty degrees.

56. An optical system, comprising:

a plurality of first optical ports operative for at least one of transmitting and receiving optical beams;

a plurality of second optical ports operative for at least one of transmitting and receiving optical beams; and

an array of first reflective devices formed on a substrate, each one of said first reflective devices being associated with one of said first optical ports and being movable across a range of angular orientations, each such orientation being defined by an axis normal to a reflective surface of said one of said first reflective devices, to optically connect said associated one of said first ports with substantially any one of said second ports, said range of angular orientations for any one of said first reflective devices being defined by a center axis having a directional orientation associated with a unit vector such that a first device set including substantially all of said first reflective devices of said array of first reflective devices defines a first center axis set including all of the center axes of said first reflective devices of said first device set and a corresponding first unit vector set including the unit vectors associated with the center axes of said first reflective devices;

said first optical ports, second optical ports and array of first reflective devices being configured such that an average orientation of said first center axis set, said average orientation of said first center axis set being the orientation of an average unit vector obtained by taking a vector sum of said unit vectors of said first unit vector set and dividing said sum by a number of said unit vectors of said first unit vector set, is angularly offset by at least five degrees and less than ninety degrees relative to an axis normal to said substrate on which said array of first reflective devices is formed.

57. The system of claim 56 wherein said first optical ports, second optical ports and array of first reflective devices are configured such that the average orientation of said first center axis set is angularly offset by at least ten degrees and less than eighty degrees relative to the axis normal to said substrate on which said array of first reflective devices is formed.

58. The system of claim 56 wherein said axis normal to said substrate on which said array of first reflective devices is formed is parallel with optical beams transmitted from said plurality of first optical ports.

59. The system of claim 56 further comprising:

an array of second reflective devices formed on a substrate, each one of said second reflective devices being associated with one of said second optical ports and being movable across a range of angular orientations, each such orientation being defined by an axis normal to a reflective surface of said one of said second reflective devices, to optically connect said associated one of said second ports with substantially any one of said first ports, said range of angular orientations for any one of said second reflective devices being defined by a center axis having a directional orientation associated with a unit vector such that a second device set including substantially all of said second reflective devices of said array of second reflective devices defines a second center axis set including all of the center axes of said second reflective devices of said second device set and a corresponding second unit vector set including the unit vectors associated with the center axes of said second reflective devices;

said first optical ports, second optical ports, array of first reflective devices, and array of second reflective devices being configured such that an average orientation of said second center axis set, said average orientation of said second center axis set being the orientation of an average unit vector obtained by taking a vector sum of said unit vectors of said second unit vector set and dividing said sum by a number of said unit vectors of said second unit vector set, is angularly offset by at least five degrees and less than ninety degrees relative to an axis normal to said substrate on which said array of second reflective devices is formed.

60. The system of claim 59 wherein said first optical ports, second optical ports, array of first reflective devices, and array of second reflective devices are configured such that the average orientation of said second center axis set is angularly offset by at least ten degrees and less than eighty degrees relative to the axis normal to said substrate on which said array of second reflective devices is formed.

61. The system of claim 59 wherein said substrate on which said array of first reflective devices is formed and said substrate on which said array of second reflective devices is formed comprise a single substrate.

62. The system of claim 59 wherein said substrate on which said array of first reflective devices is formed and said substrate on which said array of second reflective devices is formed comprise two separate substrates.

63. The system of claim 59 further comprising:

a fixed reflective surface fixed relative to said array of first reflective devices and said array of second reflective devices, said fixed reflective surface being positioned to provide an optical pathway between said array of first reflective devices and said array of second reflective devices.

64. The system of claim 59 wherein said axis normal to said substrate on which said array of second reflective devices is formed is parallel with optical beams transmitted from said plurality of second optical ports.